World Journal of Biology Pharmacy and Health Sciences, 2020, 04(03), 082–090

World Journal of Biology Pharmacy and Health Sciences

e-ISSN: 2582-5542, Cross Ref DOI: 10.30574/wjbphs

Journal homepage: http://www.wjbphs.com

(REVIEW ARTICLE)

Natural polymers in pharmaceutical drug delivery: A review

Kirteebala Pawar *, Dhawal Rajendra Shinde, Dipak Dhondu Shivgan, Sagar Namdev Sherker, Shivam Devdendra Sharma, Rishikesh Ramasare Sharma, and Smita Takarkhede

Ideal College of Pharmacy and Research, Bhal, Haji malang Road, PO: Dwarali Kalyan (W) 421306.

Publication history**:** Received on 01 December 2020; revised on 09 December 2020; accepted on 11 December 2020

Article DOI: https://doi.org/10.30574/wjbphs.2020.4.3.0101

Abstract

In pharmaceutical formulation two main ingredients are required which is API and excipient. And excipient contains many components which plays vital role in manufacturing of dosage form as well as improve pharmaceutical parameters of the dosage form. Polymers used in any dosage form as excipient. Polymers have influencing capacity towards drug release and should be compatible, stable, non-toxic and economic etc. Generally, polymers are classified into three categories i.e natural, semi-synthetic and synthetic polymers. Nowadays, many pharmaceutical companies inclined towards using natural polymers due to many problems created with drug release and side effects. Polymers plays various application in formulation as excipient like to provide uniform drug delivery, rate controlling agent, taste masking agent, protective and stabilizing agents, etc. So that this review discuss about various natural polymers, there advantages over synthetic polymers and role of polymers in designing drug delivery system.

Keywords: Polymer; Sustained Release; Dosage Forms; Plastic and Elastomers.

1. Introduction

Polymers are at the reason for noteworthy present-day items. Their speedy advancement in creation is caused, near social components, by the need to supersede conventional materials. "Polymer" was introduced by the Swedish physicist J. J. Berzelius. He thought of, for example, benzene (C_6H_6) to be a polymer of ethyne (C_2H_2). Subsequently, this definition experienced an unpretentious change (1) Polymers have been used as a principal contraption to control the drug release rate from the subtleties. Wide usage of polymers in drug transport has been recognized because polymers offer fascinating properties that have not been cultivated by some different materials. Advances in polymer science have incited the unforeseen development of a couple of novel drug movement systems. An authentic idea of surface and mass properties can help in the organizing of polymers for various prescription movement applications (2)

1.1. History

The possibility of polymers is one of the exceptional musings of the 20th century. It was created during the 1920s during deferred conversation and its affirmation is immovably related with the name of H. Staudinger who got the Nobel Prize in 1953.

1.2. Plastic

The principle plastic material relied upon nitrocellulose and was gotten by Parkes in 1862 and Hyatt in 1866. The extension of camphor to nitrocellulose provoked the principal thermoplastic (a changed normal polymer) known as celluloid. By 1900 this material was used for the film. In around 1897, Galalith (event = milk, lithos = stone) was made in Germany by reacting casein (a milk protein), with formaldehyde.[1]

* Corresponding author: Mrs Kirteebala Pawar
Ideal College of Pharmacy and Research, Bhal, Haji malang Road, PO: Dwarali Kalyan (W) 421306.

1.3. Fibers

Different sorts of customary fibers are available all around the globe and ordinary models these regular fibers consolidate cellulosic strands, wool, and animal strand Common fibers can be orchestrated into different sorts depending on their origination, for instance, plant fibers and animal strand shows the various request of typical fibers. The plant strands are all things considered apportioned into the going with classes: bast; leaf straw; seed; grass and wood filaments.[3]

1.4. Elastomers (Rubbers)

The principle notice of flexible trees is to be found in De Orbe Nuovo by Pietro Martire d'Anghiera, conveyed in Latin in 1516. The unprecedented wellspring of ordinary elastic, the gigantic woods tree Hevea Brasiliensis, occurs in the southern tropical district, on a very basic level in Malaysia, Indonesia, Thailand, Ceylon, India, Cambodia, Viet Nam, Brazil, Africa, and some various countries from Asia and South America. Such trees were assigned "Cau-much" or "wailing wood" in South-America. The name was gotten from the usage of the material as an eraser, "center around pencil means", an application introduced by Priestley in 1770. The main name of caoutchouc is up 'til now used to mean flexible in various vernaculars other than English, where it is held for the versatile hydrocarbon. [1]

2. Need

In the journey for materials with better mechanical, warm, and electrical properties, it is ending up being evident that by and large dissipating (inorganic) nanoparticles in plas-fits improve execution. Besides, blend holding (both covalent and non-covalent) between a filler and a polymer improves materials similitude, moreover, in this way improves certain properties of the polymeric system well past what is developed by straightforward doping with the filler. [4]

3. Advantages and disadvantages of polymers

3.1. Advantages

- Polymers are more impenetrable to manufactured mixes than their metal accomplices.
- Polymer parts needn't bother with post-treatment finishing tries, as opposed to metal.
- Polymer and composite materials are up to various occasions lighter than customary metals.
- Polymer materials handle far better than metals in misleadingly severe circumstances. This assembles the future of the plane and keeps up a vital good way from costly fixes accomplished by burning-through metal parts.
- Polymers are ordinarily radar light similarly as thermally and electrically ensuring.
- In clinical Facilities, polymer and composite materials are easier to clean and purify than metal.
- Polymer materials license the oil and gas industry to explore further profundities than at some other time by offering gadget weight decline without lost quality similarly as materials which offer unmatched fixing [5]

3.2. Disadvantages

- Polymers are more invulnerable to produced blends than their metal accessories.
- Polymer parts needn't waste time with post-treatment completing attempts, as opposed to metal.
- Polymer and composite materials are up to various events lighter than regular metals.
- Polymer materials handle far unmatched than metals in misleadingly furious conditions. This builds the fate of the plane and keeps up a crucial decent ways from exorbitant fixes achieved by eating up metal parts
- Polymers are consistently radar flexible comparatively as thermally and electrically making sure about.
- In clinical Facilities polymer and composite materials are less mind-boggling to clean and decontaminate than metal.
- Polymer materials award the oil and gas industry to investigate further profundities than at later by offering device weight decrease without lost quality likewise as materials which offer unequaled fixing[5]

4. Why it is superior to manufactured polymers

4.1. Natural versus Synthetic Polymer (as Biomaterial)

Normal polymers can be found in living creatures and plants; for example, silk, protein, cotton, material, wool, and DNA. Fabricated polymers, as their name shows are coordinated into the lab through a movement of substance reactions. Cases of such polymers are polyvinyl chloride, polypropylene, gnawing gum, flexible, and nylon. There is diverse biomedical use of designed and ordinary polymers. Produced characteristic polymers have various applications in drug conveyance. Ordinary polymers stood up to various issues like instability, irreproducibility, changes in feel on limit, wild arrangement brand name, etc. thusly, novel plans were expected to make in the sort of fabricated polymer by some blend estimates like polymerization. Headway of new assistant etchings could require answers for a segment of the issues that are ordinarily connected with characteristic polymers [6]

4.2. Biomedical uses of manufactured and regular polymers

Polymer	Biomedical applications
Poly(2-hydroxyethyl methacrylate)	Contact focal point
Poly (dimethylsiloxane)	Breast insert
Poly (ethylene)	Orthopedic joint inserts
Poly (ethylene glycol)	Pharmaceutical filters wound dressings
Poly (isoprene)	Gloves
Poly (propylene)	Sutures
Alginate	Wound dressings
Hyaluronic acid	Orthopedic repair matrices
Fibrin	Haemostatic product

Common polymers, for instance, collagen and elastin are generally insoluble in both water and characteristic solvents. The exceptional case is collagen removed from the tissue of energetic animals, which is dissolvable in debilitating acidic destruction. Chitosan is dissolvable in debilitate acidic destructive plan, yet the fixation that can be reached is fairly low and relies solidly upon the nuclear heap of the biopolymer. The dissolvability of collagen and chitosan in acidic destructive gives the probability to blend them in with other water dissolvable Polymers. [7]

4.3. Natural versus manufactured polymers in Tissue designing

The normally based polymer can be gotten from the sources inside the body or outside the body. One of the most generally perceived regular biomaterial found in the human body is the protein collagen. A wide scope of sorts of collagen exists in different tissues and a couple of these particular types I and II have been examined as biomaterials. Another protein base biomaterial fibrin results from the blend of blood thickening parts fibrinogen and thrombin. Both fibrin and collagen have been routinely used in tissue designing undertakings to fix tendon mischief and other muscular applications. [6]

4.4. Biomaterials in Bone tissue designing

Polymeric and bioceramic-based stages are commonly used in BTE. They are regularly advantageous in giving a sensible physical microenvironment to bone recuperation. Polymers join customary and fabricated polymers and trademark polymers, for instance, chitosan, collagen, fibrin, elastin, alginate, hyaluronic destructive, etc are biocompatible with unimportant adversarial immunological effects. Regularly happening polymers have a higher piece of slack over-designed in their high biocompatibility [23]. Chitosan is a regularly ample polymer that has been used in BTE for quite a while It is a straight polysaccharide contained glucosamine and N-acetyl glucosamine. It is essentially found in the shell-exterior of shellfish animals. Chitosan is an adversary of a microbial and significantly adaptable polymer, making it useful for some imaginative techniques. Alginate is also an ordinarily happening polymer (anionic) and has perseveringly been used in bone tissue frameworks.[8] An assortment of materials have been utilized for the

substitution and fix of harmed or damaged bone tissues. These materials incorporate metals, pottery, polymers (common and engineered), and their mixes. [9]

Numerous kinds of polymeric materials have been utilized for bone tissue engineering.4,34,81 They can be essentially classified as normally inferred materials [e.g.collagen and fibrin) and manufactured polymers (for example poly(lactic corrosive) (PLA), poly(glycolic corrosive) (PGA), and their copolymers PLGA]. Normally, inferred materials have the expected bit of leeway of natural acknowledgment that may decidedly uphold cell attachment and capacity. [9]

5. Classification of polymers

5.1. General classification of polymers

Polymers are orchestrateSd in different sorts on different reason as in the go within the particular, Classification reliant on the wellspring of the beginning, which is requested in three sorts:

5.1.1. Natural polymers

Polymers either acquired from plants or creatures are called ordinary polymers. They are called plant and creature polymers. Ex. Cellulose, Jute, Lichen, Silk, Wool, Leather, RNA, DNA, Natural flexible.

5.1.2. Semi synthetic polymers

The polymers got by essential compound treatment of trademark fibers to improve their physical properties like Celastrus nature, inflexibility is called semisynthetic strands. e g. Acidic corrosive determination rayon, Cupra ammonium silk, thick rayon.

5.1.3. Synthetic strands

The strands got by polymerization of direct substance particles in the exploration office are designed strands. e g. Nylon, terylene, polyethylene, polystyrene, designed versatile, nylon, PVC, backlite, Teflon, Orion, thus on.[10]

5.2. Classifications based on the structure are three types of polymers as follows

5.2.1. Linear polymers

In these polymers, monomers are connected and structure a long straight chain. These chains have no side chains. e g. Polyethene, PVC, Nylons, polyesters, and so forth Their particles are firmly stuffed and have a high thickness, elasticity, and dissolving point.

5.2.2. Branched polymers

They have a straight long chain with various side chains. Their particles are sporadically stuffed subsequently they have a low thickness, rigidity, and softening point, eg. Polypropylene (side chain — CH3), amylopectin, and glycogen.

5.2.3. Network or cross-connected polymers

In these monomeric units are connected to establish a three-dimensional organization. The connections included are called cross-joins. They are hard, unbending .and weak because of their organization structure, e.g. Bakelite, Maia mine, formaldehyde pitches, vulcanized elastic, etc.[10]

5.3. Classification based on molecular forces

Mechanical properties of polymers like flexibility, quality, and adaptability depend on intermolecular forces like van der Waals forces and hydrogen holding. Because of these forces, they are assigned.

5.3.1. Elastomers

These are where polymer ties are held up by the most delicate engaging forces. They contain randomly twisted nuclear chains having scarcely any cross-associations. As the stain is applied polymer gets broadened and as the force is conveyed polymer recovers its remarkable position. These polymers are adaptable and called elastomers, for instance, Neoprene, and vulcanized versatile.

5.3.2. Fibers

They have a high intermolecular engaging force like H holding. They have high flexibility and are used in material organizations, eg. Nylon-6, Nylon-66, and Terylene.

5.3.3. Thermoplastic polymers

These are the polymers having intermolecular forces among elastomers and strands. They are conveniently formed in needed shapes by warming and resulting in cooling at room temperature. They may be straight or expanded chain polymers. They are fragile in hot and hard on coding, eg. Polythene, polystyrene, PVC.

5.3.4. Thermosetting polymers

This polymer is hard and infusible on warming. These are not sensitive to warming under pressure and they are assuredly not remolded. These are cross-associated polymers and are not reused, eg. Bakelite [10]

6. Roles of polymers in drug delivery

6.1. Immediate-release dosage forms:-

6.1.1. Tablets

Polymers including polyvinyl-pyrrolidone and hydroxypropyl methylcellulose (HPMC) discover utilizes as folios that guide the development of granules that improve the stream and compaction properties of tablets' details before tableting [12]. Microcrystalline cellulose is frequently utilized as an option in contrast to starches as diluents in tablet definitions of exceptionally strong low-dose drugs [14]

6.1.2. Capsules

A significant number of the polymeric excipients used to "mass out" container fills are equivalent to those utilized in prompt delivery tablets. Gelatine has been utilized only as a shell material for hard (two-piece) and delicate (one-piece) capsules[12]. By late advances, HPMC has been acknowledged as an elective material for hard and delicate cases [13]

6.2. Modified-release measurements structure

To accomplish gastro maintenance mucoadhesive and low-density, polymers have been assessed, with little achievement up until this point, for their capacity to broaden gastric habitation time by attaching to the bodily fluid coating of the stomach and coasting on the head of the gastric substance individually [12]

6.3. Extended-discharge measurement structures

Broadened and continued delivery dose structures drag out the time that foundational drug levels are inside the restorative reach and along these lines lessen the number of portions the patient must produce to keep up remedial results in this manner expanding consistency [12]. The most regularly utilized water-insoluble polymers for broadened discharge applications are the ammonium methacrylate copolymers cellulose subsidiaries ethylcellulose and cellulose acetic acid derivation, and polyvinyl subordinate, polyvinyl acetate [13]. The helpful impact of medications that have a short natural half-life might be upgraded by planning them as broadened or supported delivery measurement forms [14]

6.4. Gastro retentive dosage Forms

Gastro retentive dose structures offer an elective procedure for accomplishing an all-encompassing delivery profile, in which the detailing will stay in the stomach for delayed periods, delivering the medication in situ, which will at that point break down in the fluid substance and gradually pass.[12],[13]

7. Role of polymers in pharmaceutical drugs delivery

7.1. Polymers as skimming drug conveyance framework

Polymers are regularly used in floating prescription movement systems to zero in on the transport of drugs to a specific territory in the gastrointestinal part for instance stomach [12]. Common polymers which have been examined for their

promising potential in stomach-unequivocal medicine transport consolidate chitosan, gelatin, thickener, guar gum, gellan gum, karaya gum, psyllium husk, starch, alginates, etc[13]

7.2. Polymers used in mucoadhesive drug delivery system

The new age mucoadhesive polymers for buccal prescription movement with central focuses, for instance, a development in the living course of action period of the polymer, entrance redesign, site-express connection, and enzymatic obstruction, site-explicit mucoadhesive polymers will indeed be utilized for the buccal transport of a wide collection of supportive compounds[12]. The class of polymers has colossal for the movement of supportive macromolecules [13].

7.3. Polymers utilized as Colon Targeted Drug Delivery

Polymer assumes a significant part in the colon focused on the drug conveyance framework. It shields the medication from debasement or delivery in the stomach and small digestive system. It additionally guarantees a sudden or controlled arrival of the medication in the proximal colon. Dextran forms opposed hydrolysis in upper GI parcel substance however were quickly debased in cecal and colonic substance where the bacterial tally is high. Chitosan containers were utilized for the colonic conveyance of an enemy of ulcerative colitis drug [12]. It additionally guarantees a sudden or controlled arrival of the medication in the proximal colon [13].

7.4. Polymers for Sustained Release

The polymer is utilized in the continued discharge framework by getting ready biodegradable microspheres containing another intense osteogenic compound [13]. To accomplish the supported arrival of 3-ethyl-4-(4-methylisoxazole's-5-yl)- 5-(methylthio) thiophene-2-carboxamide, another strong osteogenic compound for the treatment of bone problems, arranged microspheres containing BFB0261 and recently incorporated three poly (d, l-lactic corrosive) (PLA), four poly (d, l-lactic corrosive co-glycolic corrosive) (PLGA), and eight poly (d, l-lactic corrosive)- block-poly(ethylene glycol) (PLAPEG) biodegradable polymers or copolymers, and assessed the delivery example of microspheres[12]

7.5. Polymers in implantable medication conveyance Polymer

Miniature needles are of enthusiasm for implantable medication conveyance because of their upgraded biocompatibility, and capacity to adjust to tissue without breaking during the inclusion of tissue reconfiguration measures. These gadgets have been manufactured utilizing a few polymers including polydimethylsiloxane (PDMS) ;), polylactic and polyglycolic corrosive (PLGA), block copolymer hydrogels, SU-8 photoresist, and polyimide [12]

7.6. Polymeric micelles

Polymeric micelles (PMs) are created because of the quick needs of the high selectivity of medication carriers.PMs shaped from an amphiphilic block copolymer are reasonable for exemplification of ineffectively water-dissolvable, hydrophobic anticancer medications. Significantly, basic highlights of the PMs as medication transporters, including molecule size, strength, stacking limit, and delivery energy of medications permit PMs to be focused to the tumor site by a detached instrument called the improved penetrability and maintenance effect[12]

7.7. Polymers in tissue designing

A wide scope of common source polymers with a unique spotlight on proteins and polysaccharides may be conceivably valuable as transporters frameworks for dynamic biomolecules as cell transporters with application in the tissue designing field focusing on a few organic tissues [12]. Protein-situated in the tissue designing field is - collagen, gelatin silk fibroin, fibrin (fibrinogen), and Other proteins, for example, elastin or soybean are used [13]. The cell transplantation strategy is one of the most regularly utilized in ligament and bone formation [14]

7.8. Poly (lactic-co-glycolic corrosive) Microspheres

The term microsphere alludes to a little circle with a permeable internal network and variable surface from smooth and permeable to unpredictable and nonporous [14].

7.9. Polymeric Nanoparticles as Drug Carriers

Certain substance elements are either quickly corrupted or potentially processed after the organization (peptides, proteins, and nucleic acids). This is the explanation that nanotechnologies might be utilized to adjust or even to control the medication dispersion at the tissue, cell, or subcellular levels has emerged [14]

7.10. Polymers Used for the Delivery of Genes in Gene Therapy

A few polymers by having a cationic charge at physiological pH are an appropriate possibility for the exchange of qualities over the different organic hindrances plot in the first text [14].

7.11. Polymeric Vesicles

Polymeric vesicles might be created from an assortment of macromolecular amphiphile models, which include: block copolymers, irregular unite copolymers, and polymers bearing hydrophobic low-molecular-weight pendant or terminal groups [14].

7.12. Polymer Drug Conjugates

Flow research in the field of polymer anticancer medication forms is coordinated towards the distinguishing proof of the instrument of activity of free and polymer-bound medications at the cell and subcellular levels [14].

8. Polymers in pharmaceutical applications

8.1. Water-Soluble Synthetic Polymers

- Poly (acrylic corrosive) cosmetic, drugs, immobilization of cationic medications, the base for Carbopol polymers.
- Poly (ethylene oxide) Coagulant, hairy, exceptionally high molecular-weight up to a couple million, expanding specialist.
- Poly (ethylene glycol) Mw <10,000; fluid (Mw <1000) and wax (Mw >1000), plasticizer, base for suppositories.
- Poly (vinyl pyrrolidone) is used to make betadine (iodine complex of PVP) with less harmfulness than iodine, plasma substitution, and tablet granulation.
- Poly (vinyl liquor) Water-soluble bundling, tablet folio, tablet covering. Cellulose-Based Polymers.
- Ethylcellulose Insoluble however dispersible in water, fluid covering framework for supported delivery applications.
- Carboxymethyl cellulose Super disintegrant emulsion stabilizer.
- Hydroxyethyl and hydroxypropyl celluloses Soluble in water and liquor for tablet covering.
- Hydroxypropyl methylcellulose Binder for tablet framework and tablet covering, gelatin elective as content material.
- Cellulose acetate phthalate enteric coating.

8.2. Hydrocolloids

- Alginic corrosive Oral and skin drug items; thickening and suspending operator in an assortment of glues, creams, and gels, just as balancing out a specialist for oil-in-water emulsions; cover and disintegrants.
- Carrageenan Modified delivery, viscosifier.
- Chitosan Cosmetics and controlled medication conveyance applications, mucoadhesive measurement structures, fast delivery dose structures.

8.3. Water-Insoluble Biodegradable Polymers

- (Lactide-co-glycolide) polymers Microparticle–nanoparticle for protein conveyance.

8.4. Starch-Based Polymers

- Starch Glidant, a diluent in tablets and cases, a disintegrant in tablets and cases, a tablet folio.
- Sodium starch glycolate super disintegrant for tablets and containers in oral conveyance.

8.5. Plastics and Rubbers

- Polyurethane Transdermal fix backing, blood siphon, counterfeit heart, and vascular unions, froth in biomedical and modern items.
- Polyisobutylene Pressure-touchy glues for transdermal conveyance.
- Polycyanoacrylate Biodegradable tissue glues in the medical procedure, a medication transporter in nano- and microparticles.
- Poly (vinyl acetic acid derivation) Binder for biting gum.
- Poly (vinyl chloride) Blood sack, and tubing.
- Polyethylene Transdermal fix backing for the medication in glue configuration, wrap, bundling containers.
- Poly (methyl methacrylate) hard contact lenses.
- Poly (hydroxyethyl methacrylate) Soft contact lenses [14].

9. Conclusion

Polymers are the reason for huge current products. The utilization of novel polymers offers benefits as well as can end up being destructive on account of the poisonousness and different contrary qualities related to them. Care ought to be taken to appropriately choose polymers while planning a conveyance system. Polymer-based drugs are beginning to be viewed as key components to treat numerous deadly illnesses that influence an extraordinary number of people, for example, malignant growth or hepatitis. The choice of polymer assumes a significant part in drug-producing. Yet, while choosing polymers care must be taken concerning their harmfulness, drug similarity, and corruption pattern. Plan and union of novel mixes of polymers will extend the extent of new medication conveyance frameworks in the future.

Compliance with ethical standards

Acknowledgments

The authors would like to appreciate the efforts and support provided by the staff of Ideal College of pharmacy and research, university of Mumbai, Maharashtra, India

Disclosure of conflict of interest

All the authors declare that they have no conflict of interest.

References

[1] Dorel Feldman Polymer History, Designed Monomers and Polymers, 2008; 11:1:1-1

[2] Krushnakumar J Gandhi, Subhash V Deshmane and Kailash R Biyan. Int. Polymers in pharmaceutical drug delivery system: a review. Int J Pharm Sci Rev Res 2012; 14(2):57-66.

[3] Thakur VK and Thakur MK. Review: Processing and Characterization of Natural Cellulose Fibers/Thermoset Polymer Composites. Carbohydrate Polymers 2014.

[4] Nicholas Leventis, Anna Palczer and Linda Mccorkle. Nanoengineered Silica- Polymer Composite Aerogels with No Need for Supercritical Fluid Drying Journal of Sol-Gel Science and Technology 2005; 35:99–105.

[5] https://www.ques10.com/p/29070/give-advantages-and-disadvantages-of-polymers-over/

[6] Bhatia S. Natural polymer drug delivery systems. Basel, Switzerland: Springer international publishing; 2016. DOI 10.1007/978-3-319-41129-3_3

[7] Alina Sionkowska. Current research on the blends of natural and synthetic polymers as new biomaterials: ReviewProgress in Polymer Science 2011; 36 :1254–1276

[8] S. Harsha Rao, B. Harini, R. Pranav Kumar Shadamarshan, K. Balagangadharan and N. Selvamurugan. Natural, and Synthetic Polymers/Bioceramics/Bioactive Compounds-mediated

[9] Cell Signaling in Bone Tissue Engineering, International Journal of Biological Macromoleculeshttp://dx.doi.org/10.1016/j.ijbiomac.2017.09.029

[10] Liu X and Ma PX. Polymeric Scaffolds for Bone Tissue Engineering. Annals of Biomedical Engineering 2004; 32:477–486. https://doi.org/10.1023/B:ABME.0000017544.36001.8e

[11] Nuha Salih Mustafa, Mohammed A. Ali Omer, Mohamed E. M. Garlnabi and Hamed A. Ismail. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value 2013: 6.14 | Impact Factor ; 6.391

[12] Krushnakumar J Gandhi, Subhash V Deshmane and Kailash R Biyani polymers in pharmaceutical drug delivery system: a review Int. J. Pharm. Sci. Rev. Res., 2012; 14(2): 10

[13] Kaur RM. Role of Polymer in Drug Delivery. Journal of Drug Delivery & Therapeutics, 2014; 3:2011, p. 32

[14] Roy H, Sri Vajra Priya V, Krishna Roy H, Jyothi N and Lakshmi Prasanthi N. Scholars Academic Journal of Pharmacy (SAJP) . Polymers in Drug Delivery Technology, 2016; vol. 5, no. 7: 305-308.

[15] Gandhi K, Deshmane S and Biyani K. Polymers in Pharmaceutical Drug Delivery System. International Journal of Pharmaceutical Sciences Review & Research, 2012; vol. 14, no. 2, p.

[16] Gajre V, Kulkarni. Natural Polymers: A Comprehensive Review Article. International Journal Of Research In Pharmaceutical & Biomedical Sciences, 2012

[17] 5. Banger B, Shinde N, Deshmukh S and Kale B. Natural Polymers In Drug Delivery Development. Research Journal of Pharmaceutical Dosage Forms & Technology, 2014;6(1):54-7.